ON THE

TIME AND MANNER OF CLOSURE

OF THE

AURICULO-VENTRICULAR VALVES.

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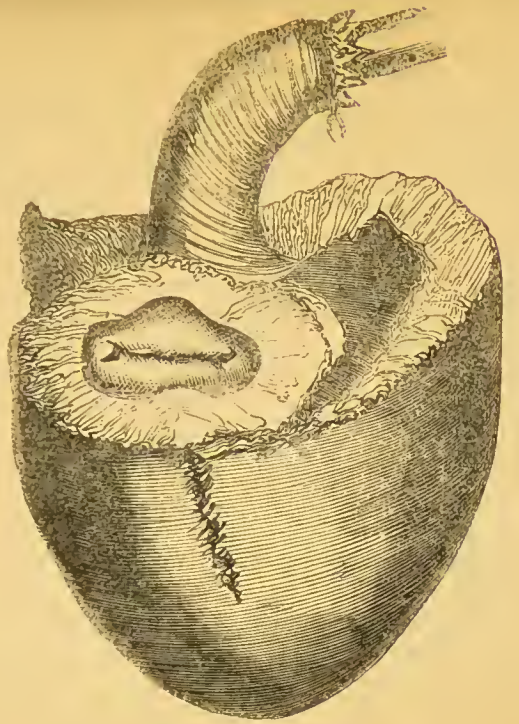
THERE are two things necessary to the closure of these valves; viz., the shutting down of the semilunar valves and auricular contraction.

When the auricle is about to inject the ventricle, the latter is empty and contracted, with its distal or ventriculo-arterial valves firmly shut down by the pressure of the blood upon their upper surfaces. Immediately the auricle contracts, its contained blood passes into (distending and lengthening) the ventricle; the force which it transmits not being sufficient to overcome the arterial pressure and weight of blood upon the upper or arterial surface of the semilunar valves, is expended in distending the ventricle and closing the auriculo-ventricular valve, which then forms one of the walls of the ventricle. (See figs. 1, 2, and 3.) To this succeeds the ventricular contraction; the auriculo-ventricular valve, being already closed, now becomes tense, the pressure in the ventricle overcomes that in the artery, and the semilunar valves are raised.

That the above is correct is proved as follows:—If we cut away the auricle and clear out the coagulum from the

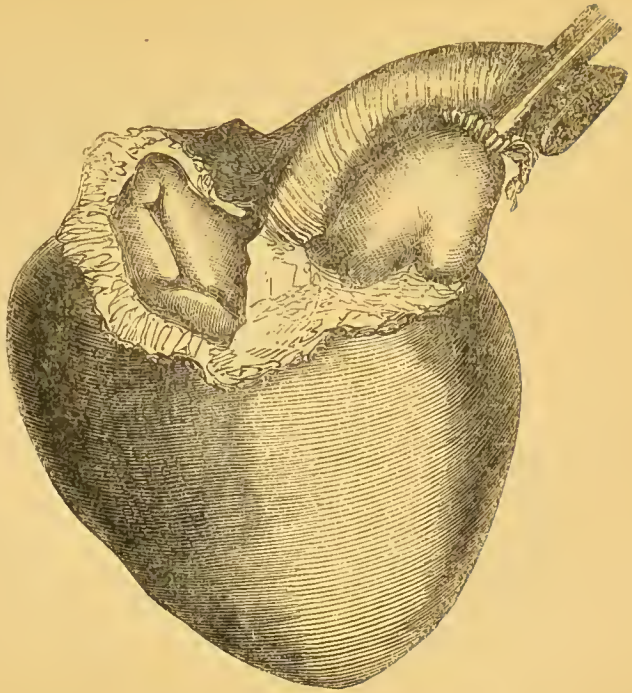
ventriele, on plaeing the heart in fluid we find that the flaps of the aurieulo-ventrieular valve are borne up to a eertain extent towards the aurieulo-ventrieular opening (see fig. 4); but the latter does not become elosed without employing foree, as with a stream of water thrown with a syringe from the direetion of the auriele, and this elosure is not perfeet nor sustained without first shutting down the semilunar valves, whieh is best done thus: for a human heart, an elastie self-supplying syringe, with a tube of like diameter with the aorta or pulmonary artery, is adapted to either vessel, and its semilunar valves shut down, gentle pressure being maintained by the fingers upon the bottle in imitation of the elastie pressure of the aorta or pulmonary artery. If the ventricle be now injeeted, the elosure of the valve is instantaneous, its upper surfaee beeoming convex (not funnel-shaped), and its under surfaee deeply eoneave (see figs. 1, 2, and 3). For a bullock's heart a plumber's foreing pump was used, and for a bird's a smaller apparatus, and with the same result in all eases. These and many other experiments upon the valves have been for some years past many times repeated; they have been performed upon the largest hearts under water with powerful apparatus purposely eonstructed.

Fig. 1.



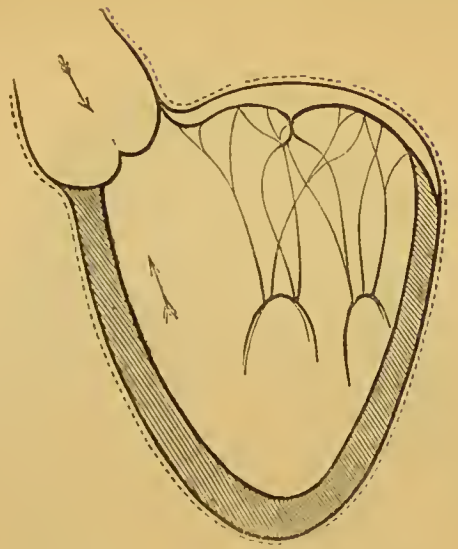
Back view of the heart; auricles cut away. The semi-lunar valves having been shut down and the aorta distended with fluid, the left ventricle was filled with water with a syringe from above, and the mitral valve closed.

Fig. 2.



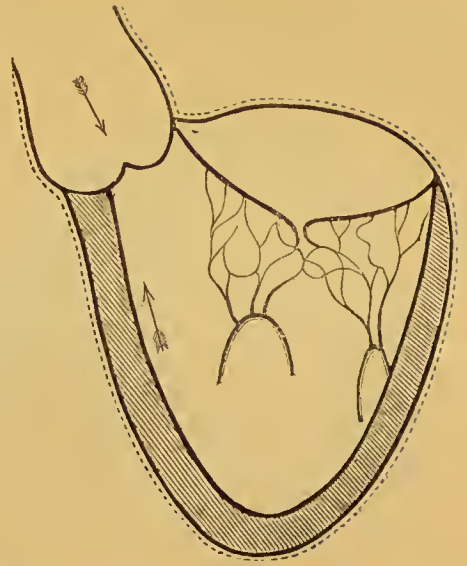
Front view of the heart; auricles removed. The pulmonic valves shut down and the artery distended. The right ventricle has been treated as the left in fig. 1, and the tricuspid valve closed.

Fig. 3.



A diagram representing the state of the ventriele immediately after its injection by the auricle. The aurieulo-ventricular valve is raised and convex on its upper surfaee, as in the preeeding figures. The eapacity of the ventriele has been inereased, its base has been raised, and at the instant of its contraetion the semilunar valves *must* open.

Fig. 4.



A diagram representing the condition of the ventriele and of the aurieulo-ventricular valve, if, as is generally tanght, the latter is closed by the contraetion of the ventriele. The upper surface of the valve is coneave, the capacity of the ventricle is thus lessened, and at the instant of its contraetion *not the semilunar, but the auriculo-ventricular valve would be raised*, by which both time and power would be lost.

The dotted line represents the perieardium, and the arrows the direction of the pressure.

From this I think it will be at once seen, that the auriculo-ventricular valve must be closed previously to the systole of the ventricle, as in figs. 1, 2, 3, otherwise the ventricle could not thoroughly be filled, nor could the valve itself perform its office properly; for as the ventricle contracts and its base descends, the valve would be made to yield towards the auricle at the very time it is required to be unyielding. But with the valve closed by the end of the auricular contraction, as in fig. 3, there is not only no chance of yielding towards the auricle, but the ventricle is in that condition to exert its power most instantaneously and effectively, as the prime mover—the *fons et origo*—of the circulation. *The rapidity and power of its action would be impaired were any of its force expended in a backward direction, had it indeed to close the auriculo-ventricular, previously to opening the semilunar, valves.*

But it may be asked, How can the force of the auricular contraction be brought to bear upon the under or ventricular surface of the valve?

The following observations point to the means by which this process is effected:—

1st. If we open a ventricle and cut away the flaps of the auriculo-ventricular valve from their attachments, both to the zona tendinea and to the chordæ tendineæ, on placing the preparation in fluid, the chordæ tendineæ rise up like stems of aquatic plants from the musculi papillares, and from the sides of the ventricle.

2nd. When the chordæ tendineæ are cut off close to the under surface of the flaps of the valve, the latter are still supported at a certain level in the fluid, and their delicate margins curl upwards towards the auricle. This latter fact is more evident in the right than in the left ventricle, and is attributed by Dr. Markham, who, I believe, was the first to remark it, to the presence of the elastic tissue entering into the structure of the valve. That this curling upwards exists is shown as follows:—

(a.) Supposing a whole valve with the upper part of the ventricle to be cut out so as to form a muscular ring with

the flaps of the valve hanging loosely; on being placed in fluid with the auricular surface *upward*, the flaps are supported and their delicate margins turn up as little scrolls.

(b.) The same preparation being placed in fluid with the auricular surface *downward*, the flaps still rise, but their edges now turn downward, which is not the case with any other part of the valve.

(c.) A piece of the right auriculo-ventricular valve having been cut out from its attachments and placed in water, the above-described curve was maintained for days.

Now, if to the above we add that the ventricle in filling is an enlarging cavity, and that this enlargement and elongation take place below the attachment of the valve to the zona tendinea, and that in this elongation and upward movement of the base the valve participates; and if we remember that, even to the last drop of blood from the auricle, there is a force causing the particles of blood within the ventricle to press upon the under surface of the valve, even after the auricular contraction has ceased (for it cannot be supposed that ever, even for an instant, the blood is at rest), then are we led to the following conclusions, viz. :—

The chordæ tendineæ by position serve to open out and prop up (as stems of water-plants do their leaves) the flaps of these valves; their firm connexion at the circumference with the zona tendinea tends also to their support; moreover, the elasticity producing the upward curl assists in the approximation of their edges; finally, the pressure exerted by the blood from the auricle brings all into play, and their closure is effected.

Who can refrain from admiring this instance of economy of time and power, by which the ventricle is assigned its one function of expulsion, and the very force which fills and distends the ventricle closes these valves? This force is auricular contraction.

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